A STUDY OF THE EFFECT OF PROCESSING UPON SOME OF THE CHEMICAL AND PHYSICAL PROPERTIES OF DRIED WHOLE MILK

BY

SHERMAN GRANT MENEFEE

B. S., University of Illinois, 1936

M. S., University of Illinois, 1939

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN DAIRY HUSBANDRY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1944

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ACKNOWLEDGMENT

This thesis is the result of a cooperative study between the Division of Dairy Chemistry and the Division of Dairy Manufactures. The author wishes to express his appreciation to Professors P. H. Tracy and O. R. Overman for their assistance during the course of this study.

The author also wishes to express his appreciation to the following persons:

Professor M. J. Prucha for the use of the facilities of the Dairy Bacteriology Division.

Mr. J. M. Trimble of The Indiana Condensed Milk Company for his interest, suggestions and cooperation.

INTRODUCTION

The present war is creating an extensive market for certain dehydrated dairy products. This is indicated by the fact that the government purchased 247,805,627 pounds of dry defatted milk solids for lend-lease purposes during 1942 which amounted to over 40 per cent of the total production. Dry whole milk purchases for the same purpose during the same year amounted to 6,422,000 pounds.

When the war is over these demands may be severely curtailed unless American and foreign markets are developed for these foods. However, home markets have shown a remarkable increase in the consumption of these products.

During the last ten years the production of defatted milk solids has been considerably higher than that of whole milk powder. This can be attributed to the fact that it is an excellent food, it can be shipped economically and it will keep exceptionally well under ordinary (room temperature) storage conditions. Such fundamental factors are prerequisites for the successful merchandising of a dehydrated food.

Manufacturers found defatted milk solids much more stable under storage conditions, consequently the industry concentrated more interest in this product. It should be mentioned at this point that the successful merchandising of dried whole milk will involve primarily the question of perishability or the length of time this food will remain edible under varying storage conditions. This and other important factors must be considered when adapting such a food to human nutrition and in judging its ultimate economic importance.

At first thought it may seem rather easy to solve the problem of desiccating and reconstituting whole milk. In a substance as complex as milk it is possible that many factors may operate independently or in combination to accelerate the age deterioration of whole milk powder. This age deterioration of the product seems to be associated largely with the fat fraction which oxidizes very readily producing a characteristic off flavor in the milk. This implies that, to produce a

whole milk powder having maximum keeping quality, the processing must be based on sound scientific facts. These facts must be correlated with a study of the factors of processing that contribute to the maximum keeping quality of the product and from these beneficial factors those must be chosen that assure the most economical processing.

EXPERIMENTAL

SOURCE OF MILK SUPPLY

Milk was secured from several sources in order to observe the effect of milk quality upon the keeping quality of the processed powder.

MILK PROCESSING

All raw milk was heated to 90°F, clarified and standardized—2.76 pounds of solids per pound of fat. After clarification the milk was preheated, condensed, homogenized (single stage) then cooled to approximately 40°F and stored at this temperature until needed for drying. All of the above processing steps were varied in order to observe their effect upon the keeping quality of whole milk powder.

SPRAY DRYING

The condensed milk, after storage at 40°F for 12 hours, was removed from storage and heated to various predetermined temperatures and spray dried with pilot plant equipment. The processing was varied in order to observe its effect upon the keeping quality of whole milk powder.

PACKAGING POWDER

Every lot of powder was divided equally and one-half of the samples were plain packed (no treatment) and the other half were packed in an atmosphere of nitrogen. One set of samples (plain and nitrogen packed) from each lot of powder were stored at 40°F. All other samples were stored at room temperature. The powder was packaged in No. 1 tin cans.

ANALYTICAL METHODS

After storage for a definite number of days a set of samples from each lot of powder were opened and analyzed. The moisture content, solubility index, acidity, flavor score, weight of powder per can, the amount of ascorbic acid, copper content of the powder and the composition of the gas in the head space of the can were determined on each can of powder. The observations were made at intervals during a 16 months storage period.

The percentages of fat and total solids in the condensed milk were also recorded.

The analytical results were recorded in five different experiments which indicate the processing variables studied.

EXPERIMENTS REPORTED

1. The effect of storage temperatures upon the keeping quality of whole milk powder.
2. The influence of preheating upon the keeping quality of whole milk powder.
3. The effect of milk concentration upon the keeping quality of whole milk powder.
4. The influence of the temperature of the milk at the time of spraying upon the keeping quality of whole milk powder.
5. The influence of packing temperature upon the keeping quality of whole milk powder.

SUMMARY AND CONCLUSIONS

EXPERIMENT 1

Storage of whole milk powder at temperatures ranging from —10 to 90°F indicated that the lower temperatures of storage retarded while storage at temperatures above 60°F accelerated oxidation of the powder.

Powder stored at —10, 0 and 40′F deteriorated slowly even when packed in an air tight container. The rate of deterioration was related directly to the temperature of storage. The oxygen content of the air sealed in the can also seemed to be a factor contributing to the deterioration of the product.

EXPERIMENT 2

Preheating milk, contaminated with copper during condensing, at a temperature of 225′F for 2 minutes or 170′F for 30 minutes improved the keeping quality of the processed powder. Preheating milk at 145′F-30″, 160′F-5″ or 170′F-4″ resulted in a processed powder that did not keep as well as the former samples which were preheated at higher temperatures.

It was suggested that the amount of carbon dioxide in the head space of a can of whole milk powder may have some relations to the rate powder deteriorates in storage. A more detailed study may show that this relationship is not consistent.

It was found to be extremely important that copper contamination be eliminated from milk that is to be used for processing whole milk powder.

EXPERIMENT 3

Condensing, a poor quality milk which was heavily contaminated with copper, 2:1 and 3.5:1 resulted in a processed powder of equal keeping quality while the powder made from the uncondensed milk was decidedly inferior in keeping quality.

EXPERIMENT 4

Spray drying the condensed milk at a temperature of 90′ and 65′F appeared to be more desirable than spraying it at 50′F but the evidence presented is not considered reliable because several variables have been introduced into the experiment which appeared to have a detrimental effect upon the keeping quality of the samples.

Spray drying milk at temperatures from 70 to 150°F with a spray pressure of 1000 pounds appeared to have produced powder of slightly better keeping quality than spray drying the condensed milk at a temperature of 120°F with the spray pressure varying from 500 to 2500 pounds.

EXPERIMENT 5

Packaging powder hot (170°), cold (79°F) and after storage at room temperature and 40°F for 28 hours had little effect on the keeping quality of the product. Packaging the powder hot seems to have produced a product of slightly better keeping quality than packaging at the colder temperatures. The efficient gas packing (low oxygen content) of a can of powder appears to be much more important than the temperature at which the powder is packed.

GENERAL CONCLUSIONS

The amount of ascorbic acid in the reconstituted samples of powder was inconsistent and there was no relationship between the amount of ascorbic acid in the product and the flavor score.

Packaging powder in an atmosphere of nitrogen preserved the keeping quality of the product. Most plain packed samples consistently scored lower than the nitrogen packed samples.

Solubility was not an important factor in samples stored at room temperature or 40°F for a period of 16 months.

Storage of samples at 40°F, compared with samples stored at room temperature, prolonged the keeping quality of most samples. This was not true of some that were heavily contaminated with copper. In general powder that was processed from good quality milk had a flavor score ranging 16 to 19 after storage at room temperature for approximately 16 months while some of the same powder stored at 40°F for the same period of time had a flavor score ranging from 16 to 21.

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VITA

The author was born in Laona, Wisconsin, on June 11, 1908. He attended grammar schools in North Dakota, South Dakota, Kentucky, and Illinois. Upon graduation from Rantoul Township High School in 1928 he enrolled in the College of Engineering—Purdue University in 1930. After completing two years of college he entered the commercial field for a period of three years. In 1934 he attended the University of Illinois and was awarded the Bachelor of Science degree in 1936 and the degree of Master of Science in 1939. He has held a full time staff appointment from September 1936 until the present time and is now Associate in Dairy Chemistry. In 1939 he was married to Florence Anderson.

The author is a member of Gamma Sigma Delta, Alpha Zeta and Sigma Xi honorary societies. He is also a member of Alpha Chi Sigma and Theta Chi, professional and social fraternities respectively.